A New Interval Finite Element Method: Computational Issues

A. Sofi and **E. Romeo**

Department of Civil, Energy, Environmental and Materials Engineering, University "Mediterranea", Reggio Calabria-89124, Italy, {Alba.Sofi, Eugenia.Romeo}@unirc.it

Keywords: *Interval Uncertainties; Finite Element Method; Improved Interval Analysis; Interval Rational Series Expansion.*

Abstract

Since the mid-1990s, the interval model of uncertainty has been applied in the context of finite element analysis giving rise to the so-called Interval Finite Element Method (IFEM), see e.g., Muhanna and Mullen (2001). The main challenge faced by researchers since the first development of the IFEM was the reduction of the overestimation of the interval solution range due to the so-called *dependency phenomenon*, see Moore et al. (2009).

The aim of this paper is to develop a novel IFEM able to provide accurate estimates of the bounds of both displacements and stresses for general structures (2D and 3D) with a large number of uncertain parameters. Without loss of generality, attention is focused on structures made of linear-elastic isotropic material with uncertain Young's modulus. In particular, Young's moduli of the FEs are modeled as independent interval variables. The key idea of the proposed method is to handle interval variables by means of the *improved interval analysis via extra unitary interval*, see Muscolino and Sofi (2012) which allows to take into account the dependencies between interval uncertainties both in the assembly and solution stages of the FE procedure. The bounds of the interval displacements and stresses are evaluated in approximate explicit form by applying the *Interval Rational Series Expansion*, see Muscolino and Sofi (2013). Attention is focused on computational issues showing that the efficiency of the proposed method can be greatly enhanced by performing a preliminary sensitivity analysis of the response. For validation purpose, the proposed bounds are compared with the exact ones given by a combinatorial procedure.

References

Moore, R. E., R. B. Kearfott and M. J. Cloud. *Introduction to Interval Analysis*. SIAM, Philadelphia, 2009.

Muhanna, R.L. and R.L. Mullen. Uncertainty in Mechanics Problems-Interval-Based Approach. *Journal of Engineering Mechanics ASCE*, 127: 557−566, 2001.

Muscolino, G. and A. Sofi. Stochastic Analysis of Structures with Uncertain-but-Bounded Parameters via Improved Interval Analysis. *Probabilistic Engineering Mechanics*, 28:152−163, 2012.

Muscolino, G. and A. Sofi. Bounds for the Stationary Stochastic Response of Truss Structures with Uncertain-but-Bounded Parameters. *Mechanical Systems and Signal Processing*, 37:163−181, 2013.